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How to Select Optimal Sites for the Establishment of *Agapeta zoegana* and *Cyphocleonus achates*, Two root-feeding Insects of Spotted Knapweed

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Selecting sites with certain characteristics can increase the successful establishment of biological control agents. The following recommendations are based on an evaluation of a broad range of site characteristics at 125 spotted knapweed sites located primarily in Montana, and in Idaho and Washington. Critical factors were significantly related to the establishment of *Agapeta zoegana* and *Cyphocleonus achates*. Strong trends were found between additional factors and establishment of these two root-feeding insects.



Figure 1. Adult *A. zoegana*.



Figure 2. *A. zoegana* larva.

Critical Factors to Consider when Selecting Sites to Release *Agapeta zoegana*:

1. **Infestation Type:** Continuous infestations of knapweed are recommended as release sites for *A. zoegana*. "Continuous" is defined as infestations primarily composed of knapweed which are not separated by large areas of bare ground or other vegetation (figure 3). Strips of knapweed, such as along roadsides, are not recommended as release sites (figure 4).

2. **Soil Type:** Sites composed of sandy clay loam or clay loam soils make the best release sites; followed by silty loam, silty clay loam and sandy loam. Sand and loam soils are least desirable.



Figure 3. Continuous knapweed infestations had the greatest insect recovery rate.



Figure 4. We do not recommend releasing *A. zoegana* in patchy or linear knapweed infestations.

Additional Factors to Consider when Selecting Sites to Release *Agapeta zoegana*:

1. **Number Released:** A minimum release of 100 *A. zoegana* is recommended. We found no differences in releases between 100-500, but establishment was highest when >500 insects were released.
2. **Infestation Size:** The minimum patch size for successful releases of *A. zoegana* is one acre. Establishment of *A. zoegana* increased as infestation size of knapweed increased.
3. **Degree of Bare Soil:** *A. zoegana* established best at sites with between 0-10% bare soil. The less bare soil, the higher degree of establishment.

4. Disturbance Factors:

Disturbance such as floods, logging, fire and road construction can have negative effects on insect establishment. Grazing had the least negative effect on *A. zoegana* (figure 5). Cultivation had the greatest negative impact on establishment. Generally, as the amount of disturbance increased, establishment of *A. zoegana* decreased.



Figure 5. Insects and sheep working together on knapweed.

5. Knapweed Root Crown Diameter:

Average root crown diameter (at or below the soil surface) should be a minimum of 7 to 10 mm. Proportion of roots infested with *A. zoegana* increased with root diameter. Highest infestation rate was in roots between 17 and 23 mm at the root crown.

Cyphocleonus achates

Critical Factors to Consider when Selecting Sites for *Cyphocleonus achates*:

1. **Multiple Releases:** Multiple releases of *C. achates* over time (in multiple years) are recommended.
2. **Infestation Size:** The minimum patch size for successful releases of *C. achates* is five acres. Establishment of *C. achates* increased as infestation size of knapweed increased.



Figure 6. Adult *C. achates*.

3. **Infestation Type:** Continuous infestations of knapweed are recommended as release sites for *C. achates*. "Continuous" is defined as infestations primarily composed of knapweed which are not separated by large areas of bare ground or other vegetation. Strips of knapweed, such as along roadsides, are not recommended as release sites.
4. **Elevation:** Releases at elevations between 3000 and 5000 feet were most successful. Next is lower elevations between 1400 and 2900 feet and last is higher elevations greater than 5000 feet.



Figure 7. *C. achates* larva.

Additional Factors to Consider when Selecting Sites to Release *Cyphocleonus achates*:

1. **Number Released:** A minimum release of 200 weevils per site is recommended.
2. **Knapweed Density:** Moderate densities, an average of 10 to 15 plants per squaremeter of knapweed, were best for establishment.
3. **Disturbance:** Disturbances such as floods, logging, fire and road construction can have negative effects on insect establishment. Grazing and fire had the least negative impact on insect establishment.
4. **Land Use:** Grazing and recreation had the least effect on insect establishment. Releases should not be made in areas characterized as wetlands.



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5. Knapweed Root Crown Diameter:

Average root-crown diameter (at or below the soil surface) should be a minimum of 10 to 12mm. Proportion of roots infested by *C. achates* increased with root diameter.

Highest infestation rates were in roots between 24 and 41 mm at the root crown.

For more information about biological control of weeds, please contact your local county Extension Service or your county Weed Control Association.

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